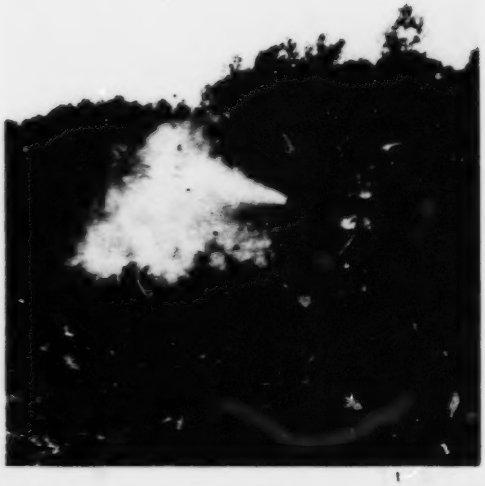
PROGRAM REVIEW 1985-86

Forest Pest Management Institute



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Canadian Forestry Service
Service canadien des forêts

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1985-86 Program Review

Forest Pest Management Institute

CANADIAN FORESTRY SERVICE
AGRICULTURE CANADA

1986

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THE CANADIAN FORESTRY SERVICE

GOVERNMENT OF CANADA

The Canadian Forestry Service is the principal source of federal expertise in forestry. Its general objective is to promote the wise management and use of Canada's forest resources for the economic, social, and environmental benefit of Canadians.

The following are the main functions of the CFS:

1. Coordination of federal policies, for the promotion of better resource management and forest industry development.

2. Provision of scientific and technological leadership in forestry through research and development.

3. Provision and analysis of national and international statistics and information as a basis for policy formulation.

4. Development and certification of codes and standards for wood product performance.

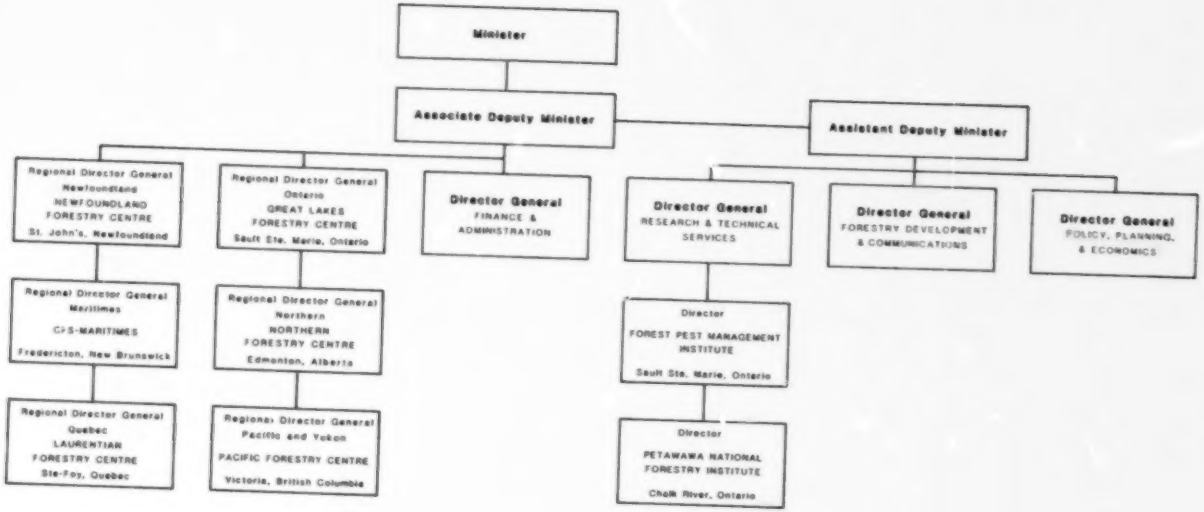
5. Protection of Canada's forests from foreign pests.

6. Fostering the potential use of the forest resource for energy.

7. Contributing to the environmental objectives of the government of Canada.

A number of federal agencies are involved in forestry programs and a Federal Forestry Sector Strategy Committee has been established to coordinate federal forestry activities. The Canadian Forestry Service has been designated the lead agency.

The Canadian Forestry Service is comprised of a headquarters unit, six forest research centres, and two national institutes. The forest research centres are responsive to regional priorities and maintain close liaison with the respective provincial government forestry departments and other clients. They also participate in, and frequently lead, national programs. The national institutes provide the focus for programs of national scope.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& COMMUNICATIONS
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POLICY, PLANNING,
& ECONOMICS

SERVICE CANADIEN DES FORÊTS

GOUVERNEMENT DU CANADA

Le Service canadien des forêts (SCF) réunit la majorité des spécialistes fédéraux en foresterie. Son objectif général est de promouvoir l'aménagement et l'utilisation judicieux des ressources forestières du Canada pour le plus grand bien économique, social et environnemental des Canadiens.

Voici les principales fonctions du SCF:

1. Coordonner les politiques fédérales afin de favoriser l'amélioration de la gestion des ressources et l'expansion de l'industrie forestière.

2. Fournir une orientation scientifique et technologique dans le domaine de la foresterie, par la recherche et le développement.

3. Fournir et analyser les statistiques et l'information nationales et internationales qui serviront à établir les politiques.

4. Mettre au point et homologuer des codes et des normes en matière de rendement des produits du bois.

5. Protéger les forêts canadiennes en luttant contre les ravageurs étrangers.

6. Parrainer l'utilisation éventuelle des ressources forestières pour la production d'énergie.

7. Adhérer aux objectifs environnementaux du gouvernement fédéral.

Divers organismes fédéraux participent aux programmes forestiers, et un comité de la stratégie forestière fédérale a été crée pour coordonner les activités fédérales en matière de foresterie. Le SCF a été désigné organisme directeur.

Le Service canadien des forêts comprend une administration centrale, six centres de recherches forestières et deux instituts nationaux. Les centres de recherches forestières doivent répondre aux impératifs régionaux et entretenir une liaison étroite avec les ministère provinciaux des Forêts. Ils participent également à des programmes nationaux dont ils assument fréquemment la direction. Les instituts nationaux sont les foyers des programmes d'envergure nationale.

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Director's Forward

Canada is a forest nation. Forestry contributes more to our balance in international trade than agriculture, mining, fisheries and fuels combined and provides one in every ten jobs in this country. It is important to the socio-economic well-being of all Canadians that Canada's share of the foreign market in wood and wood products be maintained or increased in the years to come. However, large though our forest resource may be, it is not inexhaustable and when such factors as economic accessibility, failure of natural regeneration, neglect of forest renewal on depleted productive forest lands, losses from fire, insects, diseases and competing vegetation, utilization of productive forest land for other purposes and other factors are taken into consideration, only a small margin exists for expanded future utilization. To help correct this situation, extensive programs of intensive forest renewal and forest management are currently being instituted in many areas of Canada which, to be successful, must incorporate the utilization of genetically superior planting stock, extensive programs of site preparation, suppression of competing vegetation, stand thinning and fertilization where required and more extensive use of forest protection practices to reduce losses from fire, and from destructive insects and diseases. In short, to maximize the socio-economic benefits that are achievable from our forests we must begin to farm, not mine them, and this will require utilization of all silvicultural tools available to forest managers, the dedication of the forestry community to the challenge presented and the support of the Canadian public in these essential endeavours.

The program of the Forest Pest Management Institute addresses one important component of this broader problem - reduction to acceptable levels of losses in forest production caused by destructive forest insects and competing vegetation. These losses, which, on an annual basis, have been estimated at anywhere between one-half and two-thirds of the average annual harvest, cannot be tolerated and can be reduced through development and judicious use of pest control products. Development of such control products and of strategies for their effective and environmentally benign use is the Forest Pest Management Institute's raison d'être which is in direct alignment with the overall objective of the Canadian Forestry Service, "to promote the wise management and use of Canada's forest resource for the economic, social and environmental benefit of Canadians".

As described in more detail throughout this booklet, somewhat in excess of 50 percent of the Institute's R & D program is concerned with the development of biorational control agents for use against economically important forest insect pests. Within this part of our program we conduct the fundamental and applied research required to develop microbial control agents - bacteria, fungi, viruses and protozoa - for use against forest insect pests; we investigate the use of insect growth regulators and genetic mechanisms for this same purpose; and we investigate the use of insect sex pheromones or sex attractants both for monitoring the occurrence of insect pests and for their control. This biorational control agents research is supported by fundamental research in insect tissue culture, cellular biology, immunochemistry and biological systems analysis essential for the identification of control agents, elucidation of their precise modes of action, development of improved methods for their mass production, and for determination of optimal strategies for their effective use.

A large part of the Institute's program is concerned with the development of chemical insecticides and herbicides for use against destructive forest insect pests and competing vegetation. Until biorational control agents can be developed to their full potential, we will have to rely heavily on these materials as our first line of defense in forestry and, regardless of what developments occur on the biorational side, it is almost certain that we will always have to depend upon chemical pesticides to a certain extent. Research in this area includes the toxicology and screening of new and/or improved insecticides and herbicides for forestry use, determination of their efficacy under field conditions and development of improved methods for utilizing them. To optimize the effectiveness of both chemical and biorational control agents, methods must be developed to deliver them directly to the target area in the precise amounts required to meet protection requirements and to minimize undesirable effects on other components of the forest ecosystem. The Institute is, therefore, significantly involved in application technology research including the effects of formulation properties on spray cloud emission and behaviour, and the effect of meteorological and other factors on spray cloud behaviour from emission to canopy penetration and impaction.

The responsible use of pest control products demands that their use impose minimal risk to the environment or to human health. The effects on human health lie outside the mandate of the Forest Pest Management Institute and are evaluated by appropriate federal and

provincial health agencies. The Institute is, however, heavily involved in research on the environmental impact and chemical accountability of pesticides. This research is required to determine the effects of pesticides on non-target organisms in the forest environment and the persistence, dynamic cycling and ultimate fate of these products and their metabolites in the forest ecosystem.

All of these R & D thrusts are supported by a Complementary Services Project which provides the insect, plant, and pathogen production services required to facilitate the R & D program.

This Program Review booklet is designed to acquaint the reader with the Forest Pest Management Institute, its mandate and its program. Data generated within the Institute's R & D program are essential for the development of new and/or improved pest control products for forestry use and for development of strategies for their operational use which will optimize effectiveness and minimize adverse environmental impact. In addition, Institute research provides much of the data upon which the registration status of pest control products for forestry use is determined under the Pest Control Products Act and upon which effective yet environmentally benign use patterns are developed and promulgated.

G.W. Green
Director
1 April, 1986

Microbial Control Agents

A wide variety of naturally occurring insect pathogens, including bacteria, viruses, fungi, and protozoa, can have adverse effects on the survival and reproduction of forest insect pests. To increase the number of options available to the forest manager for control of economically important insect pests, biological control research at the Institute is aimed at identifying those insect pathogens that have control potential and identifying the conditions under which they can be used to prevent insect outbreaks, or to suppress them once they have occurred. When these conditions have been identified, strategies can be developed for the use of these pathogens, either by themselves or in concert with other control methods such as chemicals.

Institute research into biological control presently concentrates on three main areas; the identification of insect-specific pathogens for control use, the elucidation of the conditions under which these organisms exert their effect on naturally occurring populations, and the development of use patterns and strategies for their effective use. These projects investigate naturally occurring host-pathogen interactions, develop data necessary to support petitions for registration of candidate pathogens, and improve application strategies for registered agents. Research into a particular organism can overlap these categories in terms of understanding its natural occurrence and effectiveness and developing it for use.

FP-10 BACTERIAL PATHOGENS

PROJECT STAFF:

P.G. Fast (Project Leader), K. van Frankenhuyzen (Study Leader), R. Milne, C. Nystrom, L. Gringorten (Post Doctoral Fellow)

OBJECTIVES: *To enhance the effectiveness of* Bacillus thuringiensis *and related bacterial pathogens for use in the control of forest insects in Canada.*

ACHIEVEMENTS: Previous work in this project has shown that the toxicity of *Bacillus thuringiensis (B.t.)* resides in the parasporal crystal produced when the bacterium sporulates. An assay for active toxin has been developed, based on the fact that some tissue culture cells react like gut cells. Serological and immunological studies have shown that most crystal types generate both specific and nonspecific antibodies. The effect of droplet size and droplet number on the efficacy of *B.t.* both in terms of mortality and feeding inhibition have been explored through bioassays. A cooperative research project called Biocide was organized to provide the knowledge necessary to tailor toxins to particular pest problems.

During 1985-86, the cooperative field experiments with Canadian Forestry Service - Maritimes, Forest Protection Limited, and Research Productivity Council continued. Biocide became fully activited. It was demonstrated, in a collaborative study with FP-22, that n-acetyl galactosamine can partially prevent toxicity from being expressed in silkworms, as had previously been demonstrated by others using tissue culture cells.

PROJECTIONS: During 1986-87, the Biocide collaboration will continue to develop, with emphasis on toxicity spectrum testing of the NRD-12 gene product and further definition of the effect of sunlight on toxicity. A quantitative cell assay using radioactive chromium will be developed and toxicity spectra in 4 insects will be determined. The susceptibility of other important forest defoliators to *B.t.* will be determined.

FP-11 FUNGAL PATHOGENS

PROJECT STAFF:

D. Tyrrell (Project Leader), Vacant (Study Leader), K. Humphries, M. Welton

OBJECTIVES: *To develop methods and procedures for the use of entomogenous fungi in the management of forest insects in Canada.*

ACHIEVEMENTS: Substantial contributions have been made by this project, since the 1950's, to an understanding of the biology of entomogenous fungi. Significant progress has been made toward the development of these fungi as control agents. Resting spore germination has been achieved for five species of entomophthoraceous fungi and many of the factors affecting germination have been determined. The resting spore germination of several *Erynia* species has been described and photoperiod effects have been documented. Epizootiological field studies have demonstrated the importance of such factors as host density and spatial distribution of the host, and the effects of inoculum density and weather conditions on the establishment and spread of fungal pathogens. Mathematical models have been designed that describe some of these interactions.

During 1985-86, physiological and biochemical studies on *Erynia radicans* continued. Bioassay trials were run to determine the efficacy of our isolates against the spruce budworm. Isozyme analysis of all our isolates of *Entomophaga* were completed and analysis of the results started. Modelling of fungus-environment and fungus-insect interactions are continuing with FP-23.

PROJECTIONS: During 1986-87, physiological and biochemical studies of *Erynia radicans* will continue, with emphasis on conditions that promote sporulation in liquid media. The effect of photoperiod on fungal growth *in vivo* will be determined. Participation will continue in the joint GLFC/FPMI budworm survivorship studies in Lake Superior Provincial Park and at Black Sturgeon Lake.

FP-12 PROTOZOAN PATHOGENS

PROJECT STAFF:

G.G. Wilson (Project Leader), E. Young

OBJECTIVES: *To investigate the host-parasite relationships of microsporidia and determine their potential and methods for use for control of forest insect pests.*

ACHIEVEMENTS: This project was initiated in 1968, and since that time has made significant progress in elucidating the occurrence and effect of microsporidia in forest insect populations. These parasites were found to have strong debilitating effects on their hosts by reducing pupal weights, adult longevity and fecundity. A quantitative bioassay was developed for microsporidia infecting the spruce budworm and forest tent caterpillar. *Nosema fumiferanae* and *Pleistophora schubergi* were tested against the spruce budworm, and *N. disstriae*, *P. schubergi*, and *Vairimorpha necatrix* were tested against the forest tent caterpillar. LD_{50}s were established and the effectiveness of each parasite was determined.

During 1985-86, the study of the field ecology/population dynamics of spruce budworm as it relates to microsporidian intensity and infection levels continued. This will be the fourth of what was originally planned as a five-year study. Laboratory tests were done on the effects of *V. necatrix* on spruce budworm.

PROJECTIONS: During 1986-87, the study of the field ecology/population dynamics of spruce budworm, as it relates to microsporidian prevalence and intensity, will continue. The parasitic microsporidia in the jack pine budworm will be compared to *N. fumiferanae* in the spruce budworm. Pathogens from submitted, or field-collected specimens of major forest insect pests will be examined.

FP-13 VIRAL PATHOGENS

PROJECT STAFF:

J.C. Cunningham (Project Leader), B. Arif (Study Leader), W.J. Kaupp (Study Leader), P.B. Jamieson, K. Brown, R. Burke, B. Cunningham.

OBJECTIVES: *To develop viruses for effective and environmentally acceptable use in the population regulation of important forest insect pests.*

ACHIEVEMENTS: For the past 35 years, this project has been devoted to the isolation, biochemical and biophysical characterization and evaluation of the population regulating potential of a variety of viruses infecting major forest insect pests. Lecontvirus, a nuclear polyhedrosis virus (NPV) for control of redheaded pine sawfly and Virtuss, an NPV for control of Douglas-fir tussock moth, received temporary registration under the Pest Control Products Act (Canada) in 1983. NPVs of eastern hemlock looper, Bruce spanworm, winter moth, forest tent caterpillar, gypsy moth and balsam fir sawfly have reached the stage of small scale field trials.

A great deal of effort has gone into the development of viruses for control of spruce budworms but results of field trials on both the eastern and western species have been less than satisfactory. Genetic manipulation of spruce budworm NPV is being considered and great progress has been made in characterizing the genetic material and studying viral protein synthesis. Polyacrylamide gel electrophoresis of proteins and restriction enzyme endonuclease analysis of DNA are used to characterize viruses with great precision for registration purposes.

Epizootiological studies have been centred on the spread and environmental fate of Douglas-fir tussock moth NPV and the build-up of gypsy moth NPV on the surface of oak leaves during a naturally occurring epizootic. Detection and quantification methods have been developed to extract and count viruses in soil samples and on leaf surfaces and to bioassay them to determine their activity.

During 1985-86, a petition for the registration of the American product, TM BioControl-1, an NPV for Douglas-fir tussock moth, was submitted to facilitate its importation and use in B.C. A petition for the registration of Sertifervirus, an NPV for control of European pine sawfly, was submitted in March 1985. Spruce budworm NPV was tested on jack pine budworm; mediocre results were obtained. Pulse chase experiments are underway to identify early, intermediate and late proteins of spruce budworm NPV. Dr. Zhang Guangyu, a visiting scientist from the People's Republic of China spent 15 months in Dr. Arif's laboratory and characterized 3 granulosis viruses isolated from *Choristoneura* spp. A method was developed for sampling gypsy moth virus inclusion bodies on leaf surfaces with double-sided sticky tape. A search was made for viruses infecting black army cutworm and three were found.

PROJECTIONS: During 1986-87, gypsy moth NPV will be developed as a biocontrol agent and registered in Canada. Virtuss will be field tested on whitemarked tussock moth. Epizootiological studies will extend to small RNA viruses that appear to be prevalent in several forest insect pests including spruce budworm. The replicative cycle of spruce budworm NPV will be studied in infected cell cultures to understand its mode of action and the events in the infected host. An attempt will be made to identify regions of the genome that code for the synthesis of various proteins. Project members hope to produce recombinants from spruce budworm NPV and alfalfa looper NPV and determine their host range.

Biological Interactions

In a research program as broad as that of the Institute there is an essential requirement for research into the biological effects of a variety of insect pest control methods, and for systems to study modes of action and identification. To conduct such research, and to develop the information required to successfully carry out other Institute projects, four areas are investigated. These are: Tissue Culture, for the study of insect pathogens *in vitro;* Cell Biology, for the identification of normal cellular development and its alteration by control agents; Immunochemistry, for identification and characterization of pathogens and their constituents; and Biological Systems Analysis, for modelling and analysis of the underlying biological systems, assistance in experimental design, and methodology for interpretation and integration of results. In addition to significant individual contributions, these projects have strong ties across the Institute's research program.

FP-20 INSECT PATHOGENS *IN VITRO*

PROJECT STAFF:

S.S. Sohi (Project Leader), G. Caputo, B. Cook

OBJECTIVES: *To develop and apply insect tissue culture methodology for the* in vitro *investigation of insect pathogens with a view to enhancing their effectiveness in the management of forest insect pests.*

ACHIEVEMENTS: Over 50 continuous cell lines have been developed from tissues of the eastern and western spruce budworms, forest tent caterpillar, whitemarked tussock moth, redheaded pine sawfly, and tobacco hornworm. Species identity of most cell lines has been confirmed by chromosomal, serological and isozyme analysis. Nuclear polyhedrosis viruses (NPV) of the original hosts have been propaged in these cell lines. Microsporidia have also been propagated in cell cultures to a more limited extent. A method has been developed for the long term storage of cell cultures in liquid nitrogen.

During 1985-86, the Project Leader was on career development leave in Japan. A plaque assay was developed for the spruce budworm NPV in one of the cell lines. Work was done on the replication kinetics and factors affecting the growth of this baculovirus in cell cultures.

PROJECTIONS: During 1986-87, work will continue on the plaque assay procedure and on factors affecting viral replications. The virus specific protein synthesis of spruce budworm NPV will be studied in infected cell cultures.

FP-21 CELLULAR INTERACTIONS

PROJECT STAFF:

Vacant (Project Leader), J.A. MacDonald, D. Nicholson

OBJECTIVES: *To investigate the differentiation of tissues and cells involved in the production of normal developmental patterns in insect embryos and larvae; as well as examining elaboration and transport of biosynthesized biologically active compounds or the transport of exogenous insect control agents.*

ACHIEVEMENTS: The production and transport of pheromones have been determined at the cellular and subcellular levels in several insect species. Such studies also identified more general mechanisms of transport of biologically active materials through cells and insect cuticle. Cooperative research with other projects has resulted in the determination of the development and structure of a microsporidian infecting the larch sawfly, confirmation of the replication of the Douglas-fir tussock moth nuclear polyhedrosis virus (NPV) in an established cell line, and development of techniques for the study of virus replication in other cell lines. Studies have been completed on the ultrastructure of the pheromone gland of the forest tent caterpillar, the mode of action of *B.t.* on gut cells, the presence and replication of tussock moth virus in cell lines, on the ultrastructure of wax gland cells in larvae of *Eriocampa ovata* and the chemical analysis of the secretion, and on the ultrastructural effect of nonylphenol on duckweed.

During 1985-86, analysis of results concerning dipteran pheromone production was completed. The study of the effect of *B.t.* on *Manduca sexta* midgut cells at low concentrations was completed. The Project Leader resigned from the Institute in July 1985 to pursue her career in the United States.

PROJECTIONS: During 1986-87, this project will become actively involved in co-operative studies with other Institute programmes. Descriptive morphological investigations of several insect viruses will be conducted to provide material suitable for publication and exhibition. Studies involving the incorporation of IGR's into insect cuticle and the toxic effect of *B.t.* on gut tissues are currently underway. A series of information reports describing the morphology of defensive glands of several insect species will be prepared.

FP-22 IMMUNOCHEMISTRY

PROJECT STAFF:

A. Pang (Project Leader), B. Mathieson

OBJECTIVES: *To develop and apply immunochemical techniques to the identification, characterization and genetic manipulation of insect pathogens, thus improving the quality of the biological pest control agents.*

ACHIEVEMENTS: Serological studies at the Institute have been closely allied to other biological control projects for the past 25 years. A large number of *Bacillus thuringiensis (B.t.)* strains and isolates were identified and characterized, contributing to a fuller understanding of taxonomic relationships. Serological techniques were also applied to the identification of FPMI cell lines, to the identification and characterization of spruce budworm viruses, and to the identification of ceratoulmin and *Gremmeniella abietina.* When the Project Leader retired in 1982 technical support was provided to other FPMI projects.

During 1985-86, with the recruitment of a Project Leader, the project was reorganized. *In vivo* studies of the mode of action of the *B.t.* crystal were carried out.

PROJECTIONS: During 1986-87, hybridomas produced at Queen's University through a 1983-84 PRUF contract will be transferred to the Institute and will be used to screen monoclonal antibodies against the *B.t.* crystal proteins for their neutralization abilities. Hybridoma technology will be established.

FP-23 BIOLOGICAL SYSTEMS ANALYSIS

PROJECT STAFF:

R.A. Fleming (Project Leader)

OBJECTIVES: *To develop and apply systems analysis methods for experimental design, statistical analysis, and strategic planning in research contributing to the solution of forest pest management problems.*

ACHIEVEMENTS: The project was established in 1980 with the goal of using systems analysis to help solve forest pest management problems. Since its inception, the project has developed spruce budworm-fungal pathogen models; contributed a systems analysis perspective in two collaborative environmental impact studies; and collaborated in developing mathematical and statistical methods for using survey data to describe short-term spruce budworm behavior and assess the effect of operational control efforts on a broad geographic basis.

During 1985-86, the model and analysis prepared for the permethrin drift study was completed. A regression model describing the relationship between songbird brain cholinesterase and Zectran applied aerially was completed. Improved methods were developed for forecasting the efficacy of pest control operations.

PROJECTIONS: During 1986-86, a procedure for handling temperature dependence in the coefficient of variation in development time for the fungal pathogen-spruce budworm model will be formulated. In a collaborative study with FP-52 on jackpine cone crop damage, programs will be provided for data entry, initial data analysis and the production of cone and conelet life tables.

Physiological & Genetic Mechanisms

A forest insect pest grows and develops through a complex and interrelated series of steps including larval and pupal stages, mating, and reproduction. As knowledge of the physiological and genetic mechanisms associated with such development becomes more complete, so do the opportunities to identify critical stages that can be manipulated to control economically important insect pests. The Institute program in this area includes research into the physiological mechanisms associated with normal growth and development, the physiological and behavioral aspects of insect mating and reproductive behavior, and the dynamics of insect population genetics. The possibility of manipulating these mechanisms, through chemical or other means, to the detriment of insect survival within a generation, and from one generation to the next arises from this research.

The research into these areas leads directly to the screening of candidate insect growth regulators and pheromones that have potential for use and the development of methods for their use. Genetic research not only identifies the stages of reproduction susceptible to manipulation, but also contributes significantly to the understanding of population dynamics and how it is affected by the application of control agents, whether they are biological or chemical.

FP-30 PHEROMONES

PROJECT STAFF:

G.G. Grant (Project Leader), D. Frech, L. MacDonald

OBJECTIVES: *To advance the use of sex pheromones and related behavior modifying chemicals for the management and monitoring of forest insect pests by providing the requisite knowledge on their chemical identification, behavioral function, and practical application.*

ACHIEVEMENTS: Since its initiation in 1967, the project has contributed to the chemical identification of five pheromones of major pest species and found attractants for another 12 species, five of which are serious pests. The oak leaf shredder attractant was successfully incorporated into a post-spray monitoring system for a semi-operational spray trial in a cooperative study. Sex pheromones were successfully applied in small-scale mating disruption trials against feral populations of six species. A bioluminescent assay was developed for measuring low levels of aldehyde sex pheromones, including that of the spruce budworm. A number of mating behavior studies carried out on several insect species provided fundamental information on this process.

During 1985-86, the effectiveness of the bio-component sex pheromone for *Dioryctria reniculelloides* was confirmed. Identification work was initiated on *D. abietivorella*. Two lures were evaluated as potential monitoring tools for the white pine weevil. Experimental analysis of the role of the sex pheromone and other stimuli in the mating behavior of the whitemarked tussock moth and spruce budworm was completed. A major part of a study on the biology and use of pheromones for monitoring the spruce seedworm on white spruce was completed. Three nonsaturating pheromone traps were evaluated against the oak leaf shredder as potential substitutes for sticky traps.

PROJECTIONS: During 1986-87, investigations will be carried out to determine whether a third pheromone component is nesessary for *Dioryctria reniculelloides*. Field tests will be carried out to evaluate recently isolated pheromone components of *D. abietivorella* and to find potential sex attractants for *Eucosoma monitorana* and *E. tocullionana*. The evaluation of nonsaturating pheromone traps for *Croesia semipurpurana* will continue and expand to include *Choristoneura conflictana*. The evaluation of white pine weevil lures will be replicated.

PROJECT STAFF:
A. Retnakaran (Project Leader), L.F. Smith, W. Tomkins

OBJECTIVES: *To evaluate and develop the rational use of Insect Growth Regulators for the control of insect pests of Canadian forests by investigating the physiological, morphological, and biochemical effects of various IGRs that adversely interfere with the normal process of metamorphosis in forest insect pests as well as in model insects.*

ACHIEVEMENTS: This project has been investigating such alternative means of forest insect control as chemosterilants, radiation, and hormone analogs since 1968. Some of the successes have been control of the spruce budworm by the moult inhibitor CGA-112913, control of the forest tent caterpillar and oak leaf shredder by Dimilin, and control of the hemlock looper by the hormone analog ZR-515. Studies have also been done on *B.t.* -induced feeding inhibition, use of juvenile hormone analogs to increase entomopathogenic virus propagation, and juvenile hormone effects on the Oleander hawkmoth as a model system for testing anti-juvenile hormone compounds. Insect or arthropod specificity of moult inhibitors has been studied by investigating the biochemical mode of action of benzoylphenyl ureas. Chitin synthesis was studied in detail to identify precisely the stage in which inhibition occurs.

During 1985-86, several new moult inhibiting IGRs from Duphar, BASF, and Dow were screened against many forest insects in the laboratory and greenhouse. JH production, anti-JH effect, and the control mechanism involved in JH production were studied in detail in the Oleander hawkmoth. The control potential of Dimilin was studied using Douglas-fir tussock moth and eastern hemlock looper. Dimilin was successfully field tested against the eastern hemlock looper in Newfoundland.

PROJECTIONS: During 1986-87, field trials will be carried out with Chevron and Tanglefoot for the prevention of white pine weevil damage in Ontario and Quebec. White pine weevil behavior will be studied in Thessalon, Ontario. The biochemical effects of juvenile hormone analog on the spruce budworm will be studied. Several new IGRs from BASF, Duphar and Sumitomo will be studied to evaluate their insecticidal effects.

FP-32 GENETIC APPROACHES

PROJECT STAFF:

In abeyance

OBJECTIVES: *To analyze the genetic components of insect reproduction, and investigate methods for manipulating pest abundance by genetic means.*

ACHIEVEMENTS: Since the project was initiated in 1972, chromosome numbers and sex determining mechanisms have been determined for more than 100 species of Lepidoptera. These mechanisms have provided a clearer understanding of the genetic complement of this group of insects. Genetic studies, carried out in collaboration with staff at GLFC, concentrated on the *Choristoneura* group and included analyses of chromosome relationships in seven species and their hybrids. The use of sterility to reduce population levels has been intensively investigated, with basic studies being carried out on mechanisms for inducing sterility, effects on treated insects, and reduction in population fertility resulting from introduction of sterile adults. The dispersal of released adult males was determined using pheromone attractants. Results indicated that the potential of this method lies with low-level isolated populations rather than large-scale epidemics.

This project was placed in abeyance in 1980 after the move of the project leader into a management position.

PROJECTIONS: Reactivation of the genetics project at the Institute will depend on availability of Person Year resources. The direction of the research is dependent on the type of genetics input required by other Institute projects in biological control.

Pesticide Toxicology & Efficacy

A wide variety of forest insect pests inflict severe damage on Canadian forests each year. The best estimates currently available suggest that the average loss in wood volume caused by the activities of our major forest insect pests approaches or exceeds some 63 million m^3 per annum. In addition, competition from undesirable tree species, grasses, and weeds often impedes the establishment, survival, and growth of desired crop species by as much as 50%. Losses of this dimension cannot be tolerated if Canada is to meet wood production goals accepted by the Canadian Council of Resource and Environment Ministers for the year 2000, or if we are to maintain Canada's share of the foreign market in wood and wood products, which is so vital to our national economy. Such losses can be prevented, or at least reduced substantially, by the judicious use of chemical pesticides. Most chemical insecticides and herbicides, however, are developed by the pesticide industry first for the agricultural use market, which is very large and stable compared to the forestry use market. Before such materials can be registered and used for forestry purposes, their efficacy against forest insect pests and unwanted vegetation must be determined and dosage rates that will balance efficacy and acceptable environmental impact must be established.

To help ensure that forest managers have a range of effective insecticide and herbicide alternatives available for their use, the Institute maintains a continuing program that screens new products and modifies formulations of existing ones, to determine toxicity against a range of target pests. Those pesticides that appear to have potential for forestry use are tested in a series of field efficacy trials to establish actual use potential, required dosage rates, and use patterns after full consideration has been given to the biology of target pests and host species. The data generated by this program become essential components of the data package that is eventually submitted in support of registration of these pesticides for forestry use under the Pest Control Products Act. They also form the basis of control recommendations to forest managers.

FP-50 INSECTICIDE TOXICOLOGY

PROJECT STAFF:

B.V. Helson (Project Leader), D. Comba, J. McFarlane

OBJECTIVES: *To determine the toxicological properties of insecticides and their formulations, and other chemicals, on forest insect pests and selected nontarget organisms and for those that show potential for use, to provide projected dosage levels and use patterns for further field testing.*

ACHIEVEMENTS: The toxicological properties of large numbers of chemical insecticides to spruce budworm larvae and numerous other forest insect pests have been investigated during the history of this project. Fenitrothion, aminocarb, acephate, and permethrin, which are all now registered for forestry use, were originally identified through this project. Recent studies include the toxicity of forestry insecticides to bees, the potential impact of permethrin drift deposits on aquatic insects using mosquito bioassays, the effects of selected factors on toxicity, and the relationship between residual toxicity and foliar residues of mexacarbate.

During 1985-86, investigations of the toxicological properties of Sumithion 20F to spruce budworm larvae were completed. Studies on the toxicity of selected insecticides to the spruce budmoth were completed. Work continued on the determination of the toxicity of certain insecticides and formulations to larvae of the eastern hemlock looper, jack-pine budworm, black army cutworm, and to white pine weevil adults. An NAE droplet generator was constructed and performance tested.

PROJECTIONS: During 1986-87, studies of the toxicological properties of Zectran, Larvin, and AC217-300 to spruce budworm will be completed and research with a new insecticide, SAN811-I, will be initiated. Extensive toxicological studies will be continued with eastern hemlock looper, jack-pine budworm and white pine weevil. The study of the toxicity of selected forestry insecticides to terrestrial insects and other invertebrates will be expanded.

FP-51 INSECTICIDE FIELD EFFICACY

PROJECT STAFF:

B.L. Cadogan (Project Leader), P. Ebling, L. Pollock, L. Zylstra

OBJECTIVES: *To develop suitable methodology and data to assess the efficacy of insecticides, formulations, and pest control strategies as required for the management of forest insect pests.*

ACHIEVEMENTS: Since its inception in the mid-1950s, this project has been primarily concerned with field efficacy testing of insecticides with potential for forestry use. Data arising from this project have been used to assess the efficacy of virtually all insecticides currently registered for forestry use in Canada today. Improved methods of applying these materials in a manner that optimizes effectiveness while minimizing environmental impact have been developed. Between 1980-1984 the project continued field studies on six insecticides and provided experimental data for registration submissions for three of them. Four types of spray dispersal equipment were examined and a technique was developed to assess sprays in conifers.

During 1985-86, Futura, Matacil flowable and Sumithion were field-tested against the jack pine budworm. The data will be used for registration submissions. A sampling apparatus that collects deposits in the mid-crown of conifers was successfully evaluated.

PROJECTION: During 1986-87, Sumithion flowable and Futura XLV will be tested against the spruce budworm. Matacil 180F will be reevaluated against the jack pine budworm. The influence of weather stability on the efficacy of aerially applied insecticides will be studied. Evaluation of the sampling apparatus will continue.

FP-52 PLANTATION PEST MANAGEMENT

PROJECT STAFF:

J. Turgeon (Project Leader), P. de Groot (Study Leader), N. Nelson, A. Obarymskyj

OBJECTIVES: *To develop adequate protection strategies for insect pests of coniferous plantations grown for seed and lumber production.*

ACHIEVEMENTS: This project has been involved in collecting biological, ecological, and behavioral information on the spruce budmoth since 1982. Insecticides have been screened for the control of this insect. Several protection strategies were identified from these studies. The project has also been actively involved in a cooperative project to establish buffer zones around bodies of water to limit the impact on aquatic arthropods of permethrin applications.

During 1985-86, all of the studies initiated in 1982 on the spruce budmoth were satisfactorily completed. Both studies combined their efforts towards the collection of basic knowledge on insect pests of cones and seeds in seed orchards and cone production areas. A Cone and Seed Pest Working Party was formed and a one day meeting was held in conjunction with the Canadian Tree Improvement Association. The study leader of the Protection Strategies and Techniques study of this Project was away on educational leave for most of this year.

PROJECTIONS: During 1986-87, the long term studies on jack and white pine, which will help develop pest management strategies for insects affecting cone and seed production in seed orchards and cone production areas, will continue. The project will expand its mandate by initiating similar studies on black spruce in northern Ontario.

FP-54 HERBICIDES DEVELOPMENT AND USE

PROJECT STAFF:

P. Reynolds (Project Leader), R. Prasad (Study Leader), J. Feng (Study Leader), T. Mackay, B. Staznick, D. Travnick

OBJECTIVES: *To develop data required for the registration of herbicides for forestry use in Canada and to develop new and improved use strategies for forestry herbicides that provide maximum crop tree growth response with minimal environmental impact.*

ACHIEVEMENTS: The FPMI herbicides project was initiated in 1981 in response to concerns that had been expressed by forest managers about the scarcity of vegetation management tools. A comprehensive protocol was established for the evaluation of new herbicides under laboratory, greenhouse, and field conditions.

During 1985-86, one year vegetation assessments of Velpar were completed. One year vegetation assessments for the Carnation Creek Watershed glyphosate trial were completed. Progress was made in greenhouse studies designed to determine the influence of droplet size on efficacy of forest weeds. Analysis of all short- and long-term water samples collected in support of the Carnation Creek experiment was completed.

PROJECTIONS: During 1986-87, two year vegetation assessments will be completed for both the 1984 New Brunswick Velpar site preparation trial and the 1984 Carnation Creek glyphosate trial. Two research symposia will be held - one on B.C. herbicides projects and one on PRUF herbicide-related projects. Greenhouse studies on droplet size and herbicide adjuvants will continue. Residue analyses for the remaining Carnation Creek samples will be completed.

Application Technology

The ultimate goal in the operational application of any pesticide by whatever application method is to assure that only the essential required amount of the pesticide is emitted, and that as much of the emitted material as possible reaches the intended target in a form that optimizes its effectiveness against the target pest. If this goal is achieved, drift beyond the target area is minimized and the effectiveness of the pesticide against its intended target is maximized.

A great number of factors affect achievement of this ultimate goal. For example, the physico-chemical characteristics of liquid sprays affect the production, size, and evaporation of the spray droplets. Dispersal system design, nozzle type, pressure, flow rate of the emission system, and speed of the vehicle carrying the emission system also influence the droplet pattern produced. Meteorological conditions during application affect the movement of the spray cloud, evaporation of the droplets, and penetration into and impaction on the forest canopy.

A thorough understanding of all of these factors and their interactions is essential if pesticides are to be applied in the most economical, efficacious, and environmentally acceptable manner. Therefore, research into all of these areas is an important aspect of the Institute's overall R & D program.

FP-61 PESTICIDE FORMULATIONS

PROJECT STAFF:

A. Sundaram (Project Leader), J. Leung

OBJECTIVES: *To assess and/or modify the physical and chemical properties of pesticide formulations in order to improve upon stability, handling, dispersal and deposition characteristics required to maximize efficacy and minimize environmental impact.*

ACHIEVEMENTS: This project was initiated in 1980. Since then it has investigated the physical properties of various pesticide formulations, tank mixes, and component materials to determine their viscosity, density, surface tension, evaporation rate, and the influence of these factors on emission characteristics through a range of emission systems. Two gravimetric methods were developed for studying comparative volatilities - one for non-aqueous pesticide formulations and spray diluents and one for water-based formulations and adjuvants. The project has also participated with other projects and outside agencies in the areas of application technology, spray deposit assessment, efficacy and environmental effects.

During 1985-86, the degree of adhesion of spray droplets of one *B.t.* and one fenitrothion formulation with and without stickers at a very low relative humidity was investigated. The role of relative humidity on droplet adhesion characteristics of three *B.t.* formulations was studied. A method was developed for determining the atomization characteristics of two pseudoplastic formulations containing biorational control agents, and two fenitrothion insecticides.

PROJECTIONS: During 1986-87, the investigation of the method of determining the atomisation characteristics of four pseudoplastic formulations containing biorational control agents will continue. A method will be developed to determine the mechanism of atomisation of herbicide formulations containing an anti-drift adjuvant. The influence of additives and temperature on the physical properties of non-aqueous pesticide formulations and diluent oils, and its relevance in ULV application will be investigated.

FP-62 SPRAY CLOUD BEHAVIOR

PROJECT STAFF:

N. Payne (Project Leader), J. Beveridge

OBJECTIVES: *To investigate and quantify the effects of physical parameters on spray cloud dispersal and deposition with the aim of increasing efficacy and reducing off-target deposit from, and cost of, forestry pesticide applications.*

ACHIEVEMENTS: The spray cloud behavior project was formed in 1970 to carry out research aimed at improving efficacy of, and reducing environmental impact from forestry insecticide applications. Meteorological variables were measured and correlated with deposit and efficacy data and the results were used to develop guidelines for meteorological conditions giving optimum forestry insecticide applications. Between 1978 and 1983 the project was without a scientist . Since 1983 the main research emphasis has been in measuring drift from forestry herbicide and insecticide applications, and developing improved sampling techniques.

During 1985-86, field experiments were carried out to measure droplet impaction efficiencies in turbulent flow, and to calibrate droplet collectors. In addition, a PRUF contract to measure dropsize spectra from herbicide atomizers was supervised, and tests were selected. Also an image analysis sytem was acquired, set-up and evaluated, and a techniqe was developed for quantifying stains on Kromekote cards.

PROJECTIONS: During 1986-87, to assist spray operators in choosing meteorological conditions in which environmental impact from herbicide (Round-up) applications is minimized, a field experiment will be carried out to measure drift and off-target deposit under a range of meteorological conditions. The calibration of droplet collectors will be continued. The spray cloud behavior and dispersal systems projects will be merged in 1986-87 to form a single project, entitled pesticide atomization and dispersal. When government restraints permit, a study leader will be recruited for the pesticide atomization study.

Environmental Concerns

Before a pesticide can be used in Canada it must be registered under the Pest Control Products Act, which is administered by Agriculture Canada. Under the terms of this Act, a pesticide must be proved effective and its use must not have a significant, adverse impact on environmental quality or on human health. To have such materials registered for forestry use in Canada and to develop the most appropriate use patterns for them, it is essential that we have an adequate understanding of their impact on non-target, naturally occurring species in the forest environment, and of their persistence, mobility, and ultimate fate in that environment. While such knowledge is essential for registration purposes, it is just as essential in adequately addressing public concerns relating to the use of these forest management tools.

A significant portion of the Institute's technical expertise and resources are directed toward determination of the effect of pesticides (chemical and biological) on non-target avian, terrestrial, and aquatic organisms in the forest environment and to elucidation of the occurrence and fate of these materials, and their breakdown products in foliage, soil, litter, water, and bottom sediment after application.

FP-70 ENVIRONMENTAL IMPACT

PROJECT STAFF:

P.D. Kingsbury (Project Leader), K. Barber, S.B. Holmes, D.P. Kreutzweiser, R. Millikin, K. Mortensen

OBJECTIVES: *To develop necessary experimental methods and carry out field and laboratory studies to determine potential environmental impacts of forest pesticides on forest ecosystems and to develop and recommend pest management strategies and pesticide use patterns to minimize these impacts under operational conditions.*

ACHIEVEMENTS: Over the past decade this project has worked with other FPMI and CFS projects to evaluate the environmental effects of numerous chemical and biological insecticides and to re-evaluate operational materials that were registered before current stringent registration requirements came into effect. Methodologies for monitoring the effects of forest pest control operations have been developed and transferred to regional and provincial agencies. More recently, emphasis has shifted to in-depth studies designed to examine in greater detail the nature and degree of risk, exposure and response of forest communities to pesticide applications.

During 1985-86, experimental fenitrothion treatments in the lower portion of the Icewater Creek research area were used for intensive studies on reactions of songbirds, pollinating insects and aquatic organisms to forest sprays. Intensive songbird population and behavior studies were coupled with exposure measurement and brain cholinesterase inhibition studies. Brook trout population studies in the upper portion of Icewater Creek continued. The aquatic impact of mexacarbate was studied to complete data requirements for a forestry registration of the insecticide. The toxicity of four forestry insecticides to a variety of aquatic invertebrates from Icewater Creek was evaluated through a PRUF program. The toxicity evaluation of six forestry insecticides against four bee species was completed.

PROJECTIONS: During 1986-87, in-house capability to conduct laboratory toxicology studies on small songbirds will be developed. Baseline studies on brook trout, aquatic invertebrates, and tracer dye movement in Icewater Creek will be completed. Pollinator risk, exposure and response to forest

insecticides will continue to be studied in a combined field and laboratory program, along with the implications on fruit set of selected forest plants. Aquatic impact studies will be carried out with the insect growth regulator diflubenzuron (Dimilin).

FP-71 CHEMICAL ACCOUNTABILITY

PROJECT STAFF:

K.M.S. Sundaram (Project Leader), C. Feng, J. Broks, R. Nott

OBJECTIVES: *To develop analytical methodology and to determine the environmental distribution, degradation, dynamics, persistence, and metabolic fate of forest insect control products in order to help in the evaluation of their benefits and potential risks to the ecosystem.*

ACHIEVEMENTS: Since its inception in 1971, this project has carried out research on the metabolism, fate, persistence, dynamics and toxic potential of organochlorines, organophosphates, carbamates, pyrethroids and IGRs, and evaluated their benefits and risks to the forest environment. The data generated by this research were used in registration packages for many products. The purity, stability and suspensibility of various technical materials in end-use mixtures were studied, in cooperation with the manufacturers, to improve the quality of products available for forestry use. Sampling techniques have been developed for the detection and characterization of pesticide residues and adjuvants in diverse forestry substrates.

During 1985-86, high performance liquid chromatography (HPLC), and gas-liquid chromatography (GLC) techniques were developed to separate and quantify permethrin isomers, mexacarbate and 7 of its metabolites in environmental samples. Techniques were designed to measure and monitor the deposition of aerially released insecticides at different conifer canopy heights and on the forest floor. Field studies were conducted to evaluate the distribution, persistence and fate of mexacarbate, aminocarb and fenitrothion in the forest environment. Involvement in the FICP Check Sample Program continued.

PROJECTIONS: During 1986-87, HPLC and GLC methods of separation and quantification of pesticides from various forestry substrates will be improved. The fate of mexacarbate in conifer seedlings will be investigated using C-14 labelled material: a metabolic pathway of its degradation will be proposed. The mobility, persistence and metabolic fate of diflubenzuron under field conditions will be studied in columns packed with forest soil horizons. The project will also participate in diflubenzuron and fenitrothion field trials to evaluate their distribution, persistence and fate in some terrestrial and aquatic components of a conifer forest environment.

Complementary Services

A wide range of services that can produce the insect species, pathogens, and plant material required for laboratory research and field testing are essential to the research being conducted at the Institute. Insects provided by the Insect Production section are used in a variety of laboratory experiment and testing programs, for production of insect viruses for field testing and operational use, and for distribution to a number of cooperators within and outside the CFS. The Pathogen Production section produces viruses for testing, and indeed, is presently the sole source for the two insect viruses registered for forestry use in Canada. The Plant Production section grows a variety of plant species required for insect food and for screening of biological and chemical insecticides, as well as representative desirable and undesirable species for use in screening of herbicides with potential for use in Canadian forestry.

FP-40-1 INSECT PRODUCTION

PROJECT STAFF:

D. Grisdale (Study Leader), K. Barratt, C. Budau, L. Harwood, H. Lauzon, A. McMorran, S. White

OBJECTIVES: *To develop and carry out insect rearing methods that will provide the numbers and varieties of insects required by Institute research projects.*

ACHIEVEMENTS: Since 1963, the insect rearing capability of this section has developed into the largest of its kind in Canada, supplying insects not only to FPMI but also to various CFS establishments, universities and other research centres in Canada and the U.S. About 10,000 litres of artificial diet are prepared and dispensed annually to support the rearing done at FPMI.

During 1985-86, about twenty insect species were reared and distributed for research. About 1 million spruce budworm in various stages of development were used locally and about 2.5 million second-instar budworm were shipped to cooperating agencies in Canada and the U.S. Large numbers of gypsy moth larvae were reared during winter months and used in a virus production program. Heavy infestations of hemlock looper and jack pine budworm have recently occurred in Canada and laboratory cultures of these pests were started at the Institute and large numbers of larvae produced for laboratory testing.

PROJECTIONS: During 1986-87, production will continue at a high level, with types and numbers reared depending on demand. The quality of all insect cultures will be improved. Attempts will continue to establish a laboratory culture of spruce budmoth.

FP-40-2 PATHOGEN PRODUCTION

PROJECT STAFF:

J. McPhee (Study Leader), H. Wigney

OBJECTIVES: *To develop, adapt, modify and apply sophisticated methodology to mass production of viruses for subsequent use in the regulation of forest insect pests.*

ACHIEVEMENTS: Since its inception in 1970, this study has produced viruses in host insect larvae in sufficient quantities to conduct experimental field trials and operational control programs. The following viruses have been produced in the laboratory: spruce budworm, *Choristoneura fumiferana* nuclear polyhedrosis virus (NPV), granulosis virus (GV), and entomopoxvirus (EPV), Douglas-fir tussock moth, *Orgyia pseudotsugata* NPV, forest tent caterpillar, *Malacosoma disstria* NPV, Bruce spanworm, *Operophthera bruceata,* NPV, and winter moth, *O. brumata,* NPV. The NPVs of the colonial species of sawflies, European pine sawfly, *Neodiprion sertifer* and redheaded pine sawfly, *N. lecontei* are routinely propagated in heavily infested plantations. These viral insecticides have been named Sertifervirus and Lecontvirus respectively, and Douglas-fir tussock moth NPV, which we have been stockpiling since 1977 in anticipation of outbreaks of this pest in B.C., has been named Virtuss.

During 1985-86, spruce budworm, Douglas-fir tussock moth and alfalfa looper NPVs were produced. The alfalfa looper NPV was for trials on black army cutworm, *Actebia fennica.* Lecontvirus was supplied to OMNR staff in 7 districts and Sertifervirus to staff of NeFC to treat scattered outbreaks of European pine sawfly in St. John's, Nfld. Production of gypsy moth, *Lymantria dispar,* NPV was initiated after permission was received from the Quarantine Division of Agriculture Canada to rear this insect during the winter months at the Institute.

PROJECTIONS: During 1986-87, virus production will continue to meet Institute research needs and requests from clients. A search will be made for a suitable liquid formulation for viral insecticides and methods for production of gypsy moth NPV will be established and evaluated.

FP-40-4 GREENHOUSE & ANIMAL SERVICES

PROJECT STAFF:

D. Buckley (Study Leader), S. MacLeod

OBJECTIVES: *To adapt, develop, extend and apply sophisticated methodology in plant production and animal rearing that will provide, as required, material for use in the Institute's research programs.*

ACHIEVEMENTS: The greenhouse services provide year-round a wide range of food plants and oviposition material for use by the Rearing Services. For the experimental research program, large numbers of potted trees are provided, at appropriate stages of development for greenhouse testing of Insect Growth Regulators, insecticides, and herbicides.

During 1985-86, approximately 3600 potted trees were supplied to researchers for screening tests. Approximately 520 larch, balsam fir, and jack pine were flushed to provide foliage for insect food. Small amounts of alfalfa, beans, potato, and wheat were grown for insect food or small experiments. Approximately 10 kg of selected mulberry foliage were provided weekly and 10 oleander and 10 tomato plants were produced at 6 week intervals as insect food and substrates for oviposition.

PROJECTIONS: During 1986-87, greenhouse services will be maintained, culture methods will be improved and the inventory of plant material will be increased.

Information & Technical Services

No research can be considered complete until the results have been transferred effectively to potential users. FPMI is closely associated with other federal departments, other governments, private industry, and the Canadian public. It is therefore essential that results from the FPMI research program reach the publics for which they are intended. The Scientific Editing and Information Services Unit is responsible for: developing and modifying the packaging and format of reports to meet changing demand; providing an editorial capability in both official languages; preparing and issuing regularly issued publications according to schedule; and, responding to requests for information.

The Information and Technical Services Unit at the Institute provides these and other services, contributing in a significant manner to the overall program at FPMI.

FP-93 SCIENTIFIC EDITING AND INFORMATION SERVICES

PROJECT STAFF:

K.B. Griffiths (Project Leader), S.A. Stitt

OBJECTIVES: *To publish and disseminate scientific and technical information that arises from the Institute's program in the most appropriate form to facilitate the transfer of forest pest management science and technology to user groups.*

ACHIEVEMENTS: This project was reviewed and reorganized in 1983, when the original Project Leader left the Institute. Since then the project has provided editorial, publishing, graphics and information distribution functions for the Institute.

During 1985-86, the Bilingual Technical Editor accepted a transfer to the Laurentian Forestry Centre: the Headquarters Editorial group has since agreed to do French editing for the Institute. The project handled the publication of 25 journal papers, 3 English information reports, 3 french information reports, 3 issues of the Newsletter, the annual Program Review and various miscellaneous reports. During the year, 2583 journal reprints, 1029 information reports, 441 technical notes and 90 french publications were distributed. A computer bibliography with abstracts of all current publications was set up. Involvement in the production of an audio visual production on FPMI continued, but with a different script writer and production crew.

PROJECTIONS: During 1986-87, effective and efficient editing and production of Institute R & D publications will continue. The audio-visual presentation of FPMI will be completed. The project will be involved in the organization of an openhouse during the fall of 1986.

Administration & Common Support Services

Administrative Support Services (material management, records management, office services, fleet management, operation and maintenance of physical plant) and financial services are provided to both the Forest Pest Management Institute and the Great Lakes Forestry Centre through one administrative unit carried on the Great Lakes Forestry Centre allocation but responsible to the Directors of both establishments. Integration of these services has been total since 1978. Some economies in staff have resulted. These integrated services have functioned in a highly satisfactory manner since their inception, and are considered the most appropriate organizational option for sister establishments of the same service sharing the same physical facility.

Integrated joint library services are provided to both establishments in a similar fashion with permanent library staff carried on the Great Lakes Forestry Centre allocation. This, too, has resulted in some economies in both staff and library space with the added advantage that library equipment and other facilities do not have to be duplicated.

As opportunities present themselves in the future, the desirability of further integration of common support services will be investigated thoroughly with the Great Lakes Forestry Centre.

FP-97 ADMINISTRATION, FINANCIAL AND ENGINEERING SERVICES

PROJECT STAFF: (GLFC)

OBJECTIVES: *To provide effective and efficient administrative and financial services in support of FPMI's program; to provide adequate physical facilities within which the Forest Pest Management's R & D program can be carried out and to ensure that these are operated and maintained in the most efficient and effective manner.*

ACHIEVEMENTS: One administrative unit, carried on the Great Lakes Forestry Centre (GLFC) allocation, has served both GLFC and FPMI since the latter was formed in 1977-78. Engineering Services were integrated in 1977 and the remainder of administrative and financial services followed in the beginning of fiscal 1978. This integrated system has served both establishments in a highly satisfactory manner to date.

During 1985-86, the major project was the ongoing construction of the laboratory and administration additions to the main complex. The administration addition was occupied in July 1985 and the laboratory addition was occupied in April 1986. Phase III - major renovation to existing facilities - was begun.

PROJECTIONS: During 1986-87, demolition of the Cameron Building and all necessary landscaping will be carried out. Phase III will be completed. The administration unit will continue to function in an efficient manner.

FP-94 LIBRARY SERVICES

PROJECT STAFF: (GLFC)

OBJECTIVES: *To develop, maintain and improve a research library commensurate with the changing requirements of the combined programs of the Great Lakes Forestry Centre and the Forest Pest Management Institute.*

ACHIEVEMENTS: The joint library has served both FPMI and GLFC well since its inception in 1978. It provides roughly 400 journals, 24 abstracting journals, and 8,000 reference texts to its clients at the two establishments.

During 1985-86, cuts were made in suscriptions to scientific journals because the devalued Canadian dollar and inflated journal prices made it impossible to maintain all subscriptions. An electronic mail system was acquired. Circulation showed a 12% increase over 1984-85, and outgoing interlibrary loans increased by 33%. Most other aspects of the library also showed a significant increase over the previous year.

PROJECTIONS: During 1986-87, new library services will continue to be investigated and recommended. Small scale seminars and demonstrations will be held on the on-line services offered by the library.

Appendices

FOREST PEST MANAGEMENT INSTITUTE
EXPENDITURES 1985-86
($000s)

PROGRAM AREA	PERSON YEARS	SALARIES	OPERATIONS & MAINTENANCE	CAPITAL	TOTAL
Management	5.0	198.6	42.7	51.2	292.5
Finance & Administration	—	—	214.3	176.8	391.1
Physical Plant	—	—	249.6	3.9	253.5
Sci. Editing & Information	3.0	77.2	29.5	20.3	127.0
Library	—	—	54.9	—	54.9
Complementary Services	13.0	336.0	34.2	7.5	377.7
Microbial Control Agents	17.0	601.2	88.5	124.0	813.7
Biological Interactions	10.0	328.9	14.4	12.6	355.9
Physiological & Genetic Mechanisms	6.0	243.7	29.6	61.4	334.7
Pesticide Toxicology & Efficacy	18.0	601.3	113.5	99.0	813.8
Application Technology	5.0	161.9	24.9	15.5	202.3
Environmental Concerns	10.0	341.4	37.4	60.0	438.8
TOTAL:	87.0	2,890.2	933.5	632.2	4,455.9

FOREST PEST MANAGEMENT INSTITUTE
RESEARCH & DEVELOPMENT CONTRACTS 1985-86

CONTRACTOR	TITLE	AMOUNT ($)	SCIENTIFIC AUTHORITY
	1. From A-Base O & M		
N.B. Research and Productivity Council	Relationship between concentration of *B.t.* in spray droplets and efficacy against spruce budworm	5,000	P. Fast (FP-10)
H. Kaplan University of Ottawa	Documentation of the presence of minimal protein constituents what may be responsible for sunlight degradation of toxicity of the *B.t.* crystal protein	24,200	P. Fast (FP-10)
H. Foller Laurentian University	Effect of insect gut proteases on the toxicity spectrum of *B.t.*	5,500	P. Fast (FP-10)
R.G.H. Downer University of Waterloo	Studies of the binding of *B.t.* to cells of *Choristoneura fumiferana* CF-1	5,500	P. Fast (FP-10)
	SUBTOTAL (A-Base R & D Contracts)	40,200	
	2. PRUF Contracts		
G.A. Surgeoner University of Guelph	Evaluation of insecticides used in spruce budworm control on non-target aquatic organisms utilizing a flow-through stream system	33,700	P.D. Kingsbury (FP-70)
G. Geen Simon Fraser University	Evaluation of a forestry herbicide (Garlon) on the ecology of juvenile salmonids in the Skeena River watershed	43,300	P.D. Kingsbury (FP-70)
J. Roder Queens University	Production of monoclonal antibodies against components of baculoviruses	19,800	W. Kaupp (FP-13)

CONTRACTOR	TITLE	AMOUNT ($)	SCIENTIFIC AUTHORITY
	2. PRUF Contracts		
P.J. Krell University of Guelph	DNA replication and genetic engineering of spruce budworm nuclear polyhedrosis virus	48,900	B.A. Arif (FP-13)
K.N. Slessor Simon Fraser University	Synthesis of high purity sensio-chemicals for cone and seed insect pests	18,900	G.G. Grant (FP-39)
G.R. Stephenson and K.R. Solomon University of Guelph	Leachability, persistence and lateral movement of triclopyr (Garlon) in selected Canadian forest soils	11,200	P. Reynolds (FP-54)
D.N. Roy University of Toronto	Persistence, movement and degradation of hexazinone (Velpar) in selected Canadian forest soils	14,600	R. Prasad (FP-54)
D.N. Roy University of Toronto	Analytical methodology development and determination of the leachability, persistence, degradation and lateral movement of glyphosate (Roundup) in selected Canadian soils	7,700	J. Feng (FP-54)
G.R. Stephenson and K.R. Solomon University of Geulph	Determination of the persistence of hexazinone (Velpar) in northern Ontario aquatic environments	17,100	P. Kingsbury (FP-70)
G.R. Stephenson and K.R. Solomon University of Guelph	Determination of the persistence of triclopyr (Garlon) in northern Ontario aquatic environments	17,700	P. Kingsbury (FP-70)
J.P. Kimmins University of British Columbia	Effect of glyphosate on the nutrient budget of a forested watershed and the persistence of glyphosate and triclopyr residues in the ecosystem	9,900	P. Reynolds (FP-54)

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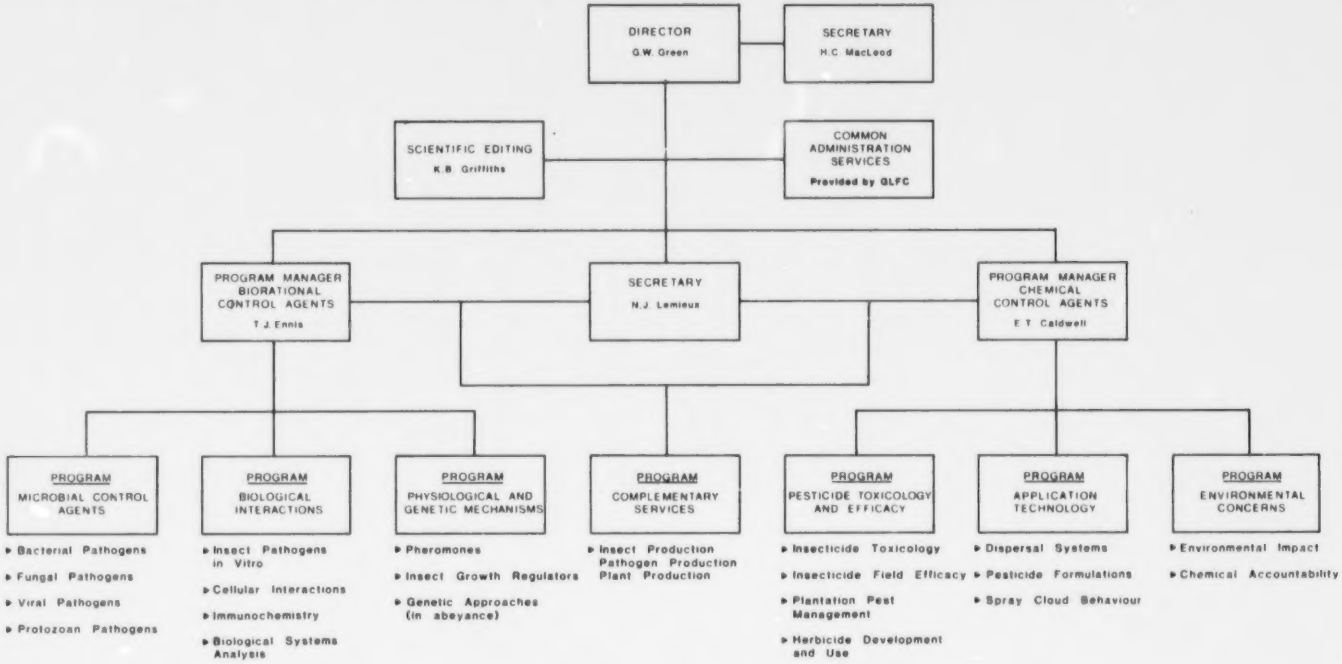
CONTRACTOR	TITLE	AMOUNT ($)	SCIENTIFIC AUTHORITY
	2. PRUF Contracts		
D.N. Roy University of Toronto	Persistence and translocation of glyphosate on competing vegetation (wild blueberry and red raspberry) following operational applications of herbicides	28,800	R. Prasad (FP-54)
J. Picôt University of New Brunswick	Droplet size spectra generated by atomizers used in herbicide and insecticide aerial applications	27,000	N. Payne (FP-62)
J.P. Kimmins University of British Columbia	Comparison of the effects of herbicide and manual conifer release on conifer seedling physiology, growth response and some aspects of ecosystem functions	21,200	P. Reynolds (FP-54)
	SUBTOTAL (PRUF Contracts)	319,700	

FOREST PEST MANAGEMENT INSTITUTE - PROGRAM ORGANIZATION



FOREST PEST MANAGEMENT INSTITUTE
ORGANIZATION & STAFF LISTING
(As of 31 March, 1985)

Director	Dr. G.W. Green Secretary: H.C. MacLeod
Program Managers	Dr. T.J. Ennis Deputy Director
	Mr. E.T.N. Caldwell
	Secretary: N.J. Lemieux
Administrative Officer	M.J. Parent Great Lakes Forestry Centre
Scientific Editing	K.B. Griffiths, Editor S. Stitt

RESEARCH & DEVELOPMENT PROJECTS

MICROBIAL CONTROL AGENTS

Program Manager: Dr. T.J. Ennis

Project No.	Title	Scientific Staff	Technical Staff
FP-10	Bacterial Pathogens	Dr. P.G. Fast (Project Leader) K. van Frankenhuyzen (Study Leader)	R. Milne C. Nystrom
FP-11	Fungal Pathogens	Dr. D. Tyrrell (Project Leader)	K. Humphries M. Welton
FP-12	Protozoan Pathogens	Dr. G.G. Wilson (Project Leader)	E. Young

Program Manager: Dr. T.J. Ennis

Project No.	Title	Scientific Staff	Technical Staff
FP-13	Viral Pathogens	Dr. J.C. Cunningham (Project Leader) Dr. B.M. Arif Dr. W.J. Kaupp Mr. P.B. Jamieson	K. Brown R. Burke B. Cunningham

BIOLOGICAL INTERACTIONS

Program Manager: Dr. T.J. Ennis

FP-20	Insect Pathogens *in vitro*	Dr. S.S. Sohi (Project Leader)	G. Caputo B. Cook
FP-21	Cellular Interactions	Vacant (Project Leader)	J.A. MacDonald D. Nicholson
FP-22	Immunochemistry	Dr. A. Pang (Project Leader)	B. Mathieson
FP-23	Biological Systems Analysis	Dr. R.A. Fleming (Project Leader)	

PHYSIOLOGICAL & GENETIC MECHANISMS

Program Manager: Dr. T.J. Ennis

FP-30	Insect Pheromones	Dr. G.G. Grant (Project Leader)	D. Frech L. MacDonald
FP-31	Insect Growth Regulators	Dr. A. Retnakaran (Project Leader)	L.F. Smith W. Tomkins
FP-32	Genetic Mechanisms	Dr. T.J. Ennis (Project in temporary abeyance)	

PESTICIDE TOXICOLOGY AND EFFICACY

Program Manager: Mr. E.T.N. Caldwell

FP-50	Insecticide Toxicology	Dr. B.V. Helson (Project Leader)	D. Comba J. McFarlane

Program Manager: Mr. E.T.N. Caldwell

Project No.	Title	Scientific Staff	Technical Staff
FP-51	Insecticide Field Efficacy	Mr. B.L. Cadogan (Project Leader)	P. Ebling L. Pollock B. Zylstra
FP-52	Plantation Pest Management	Dr. J. Turgeon (Project Leader) Mr. P. deGroot	N. Nelson A. Obarymskyj
FP-54	Herbicide Development and Use	Dr. P. Reynolds (Project Leader) Dr. R. Prasad Mr. J. Feng	B. Staznick D. Travnick

APPLICATION TECHNOLOGY

Program Manager: Mr. E.T.N. Caldwell

FP-60	Dispersal Systems	Vacant (Project Leader)	
FP-61	Pesticide Formulations	Dr. A. Sundaram (Project Leader)	J. Leung
FP-62	Spray Cloud Behavior	Dr. N. Payne (Project Leader)	J. Beveridge

ENVIRONMENTAL CONCERNS

Program Manager: Mr. E.T.N. Caldwell

FP-70	Environmental Impact	Mr. P.D. Kingsbury (Project Leader) Mr. K. Barber Mr. S. Holmes	D.P. Kreutzweiser R. Millikin K. Mortensen
FP-71	Insecticide Chemical Accountability	Dr. K.M.S. Sundaram (Project Leader) Mrs. C. Feng	J. Broks R. Nott

COMPLEMENTARY SERVICES

Program Manager: Dr. T.J. Ennis
Mr. E.T.N. Caldwell

Project No.	Title	Scientific Staff	Technical Staff
FP-40-1	Insect Production	Mr. D. Grisdale (Study Leader)	K. Barratt C. Budau L. Harwood H. Lauzon A. McMorran S. White
FP-40-2	Pathogen Production	Mr. J. McPhee (Study Leader)	H. Wigney
FP-40-4	Greenhouse Services	Mr. D. Buckley (Study Leader)	S. MacLeod

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